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THE ROLE OF LANGUAGE IN BEHAVIOR

Technical Report Number 10

IMPLICIT VERBAL CHAINING IN PAIRED-ASSOCIATE LEARNING[1]

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The role of covert symbolic processes in behavior determination has been emphasized by many psychological theorists, but the relative lack of supporting experimental evidence for this influence has been noted by several writers (2; 8, p. 110). Among the various factors deemed relevant to the operation of mediational or symbolic processes, the verbal habits of the individual have been prominently suggested. The work of Foley and Cofer (3) on verbally mediated generalization, and of Bousfield (1), Jenkins and Russell (6), etc. working with recall, have established that the influence of such verbal associations can be studied effectively under experimental conditions.

While the mediational role of word associations has been demonstrated in several performance situations, there are surprisingly few studies which report positive findings with regard to the effects of mediated associations upon learning. Bugelski and Scharlock, using paired-associate learning and nonsense syllables, have provided what they term a "reasonably clear-cut demonstration of mediated association in the learning of verbal material." (2, p. 337) Their subjects showed facilitated learning of A-C associates when another term, B, presumably intervened between A and C as a consequence of previous learning of associations A-B and B-C. The term B, then, provided an implicit common term which was elicited by A and which in turn tended to elicit C. This mediation of the correct response C occurred even though the subjects did not report deliberate use of the common term as a mnemonic device. The Bugelski and Scharlock data provide a much clearer instance of mediation than did the earlier experiments of Peters (12). Although the latter obtained some positive results, the majority of his test situations failed to demonstrate mediational effects.

Both Bugelski and Scharlock and Peters worked with associations learned within the context of the experiment and neither considered situations involving more than one intervening term. Nevertheless, applications of the mediation hypothesis have frequently referred to existing language habits and have almost always involved reference to a "chain" of several intervening terms which are linked on an associative basis. Uni-process theorists who, according to Harlow (4, p. 452) maintain that "thinking is dependent only upon the formation and appropriate elicitation of a vast number of simple associations" have most commonly assumed that (a) mediational effects can occur across several intervening terms, and (b) these influences are at least as strong for associations between real words as between nonsense syllables. Hull's concept of pure stimulus acts (5), Miller's extension of the notion of verbally mediated generalization (10, p. 181), and Osgood's discussion of thinking (11, p. 638) are but a few examples in which one or the other of these assumptions has been made. However, neither Peters nor Bugelski and Scharlock provide a basis for these assumptions.

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[1] This study is part of a larger series of studies of verbal behavior being conducted at the University of Minnesota, sponsored by the Office of Naval Research (Contract No. N8 onr-66216) under its policy of encouraging basic research.

The purpose of this experiment was to test the adequacy of the above assumptions by observing the effects of mediating verbal processes on paired-associate learning when the mediating process is implemented in part by pre-existing language habits and extends over more than one implicit verbal term.

Method

__Design.__ The design of this study was similar to that of Bugelski and Scharlock (2). Their subjects learned three paired-associate lists: list one established A-B associations; list two, B-C associations; and list three tested for mediation effects in the learning of A-C associations. In the study reported here, real words were used rather than nonsense syllables, and two implicit terms rather than one linked the pairs learned on the test trials. Here, the learning of list one established A-B associations. The B term was in each case a stimulus word from the Kent-Rosanoff association test (7). Recently obtained norms for responses on this test[2] then made it possible to infer certain B-C associations without establishing them experimentally. Similarly, other unpublished studies provided normative data concerning the most frequent associative responses (D) made to the C terms. Thus, once the A-B associations were learned, it was possible to infer an associative chain leading from A to B to C to D. The test for mediational effects was made by requiring S's to learn a list containing A-D pairings and appropriate control pairings (A-X) of non-chained terms. It was hypothesized that the A-D pairings would be learned more easily than the A-X pairings. The manner in which associative chains might facilitate the elicitation and learning of A-D pairs is schematically illustrated below. In the diagram, broken arrows indicate the association to be learned in each list. Solid arrows represent associations established before a list is learned. It can be seen that associations existing before the learning of the test list provide an indirect linkage of the A and D terms which must become associated in the chaining paradigm. In the control paradigm, a similar linkage exists between A and D, but no such connection can be inferred between the A-X pairs which are to be learned.

	List one	Associations inferred from norms	List two (test list)
Chaining Paradigm	$A_1 \cdots\!> B_1$	$(B_1 \rightarrow C_1 \rightarrow D_1)$	$A_1 \cdots\cdots\cdots\cdots\!> D_1$ $\searrow (B_1 \rightarrow C_1) \nearrow$
Control Paradigm	$A_2 \cdots\!> B_2$	$(B_2 \rightarrow C_2 \rightarrow D_2)$	$A_2 \cdots\cdots\cdots\cdots\!> X_2$ $\searrow (B_2 \rightarrow C_2 \rightarrow D_2)$

__Construction of Paired-Associate Lists.__ Table 1 contains the nonsense syllables, the particular associative chains, and the control words used throughout the experiment. List one (A-B pairings) was made up of the nonsense syllables in Column A and the corresponding words in Column B. Columns B, C and D list the verbal associative chains $(B \rightarrow C \rightarrow D)$ derived from the normative tables.

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[2] Revised norms for 100 words from the Kent-Rosanoff word association test were obtained from 1026 students in beginning psychology classes at the University of Minnesota. This work was carried out as part of a larger project on verbal behavior. Information concerning these norms may be obtained from the authors.

Two test lists were formed. One combined the first five nonsense syllables of Column A with the five corresponding words of Column D and the last five nonsense syllables with the corresponding words of Column X. The other combined the first five nonsense syllables in Column A with the five corresponding words of Column X and the last five nonsense syllables with the five corresponding words of Column D. Thus the two lists were counterbalanced and each contained five A-D and five A-X pairs. The response words of form 1 of the test list are followed by a (1) in the table; the remaining words made up form 2.

Table 1

Nonsense Syllables, Associative Chains, and Control Words Used in Forming the Paired-Associate Lists

A Nonsense Syllable	B First Chained Word	C Second Chained Word	D Final Chained Word	X Control Word
CEF	STEM	FLOWER	SMELL(1)	JOY
DAX	MEMORY	MIND	MATTER(1)	AFRAID
YOV	SOLDIER	ARMY	NAVY(1)	CHEESE
VUX	TROUBLE	BAD	GOOD(1)	MUSIC
WUB	WISH	WANT	NEED(1)	TABLE
GEX	JUSTICE	PEACE	WAR	HOUSE(1)
JID	THIEF	STEAL	TAKE	SLEEP(1)
ZIL	OCEAN	WATER	DRINK	DOCTOR(1)
LAJ	COMMAND	ORDER	DISORDER	CABBAGE(1)
MYV	FRUIT	APPLE	RED	HAND(1)

Note.--The words and syllables were presented in capital letters exactly as above. The response words of form 1 of the test list are followed by a (1).

The ten nonsense syllables of Column A were selected from Melton (9), and all had Glaze association values of zero per cent. The ten verbal chains listed in Columns B, C and D of the table were selected so that as far as the norms would indicate, no word in any chain appeared among the ten most frequent responses to any word in any other chain. In addition, no final word (D) in a chain appeared as a response to the first word (B) more than seven times in the 1026 responses to that word in the norms. It may be noted that while Column C is essential to the construction of the ten associative chains, no words in that column appeared in any of the experimental lists. The control words in Column X were chosen from the Kent-Rosanoff list such that none appeared among the ten most frequent responses to any of the chained words and no chained word appeared among the ten most frequent responses to a control word. Finally, the control words were matched with the final words of each chain on the basis of Thorndike-Lorge (13) frequency as a partial equalization of difficulty between control and experimental words.

Procedure. Twenty-seven sophomore girls from a beginning psychology class served as subjects.

Following general instructions on paired-associate learning, each S learned list one on a standard Hull-type memory drum. Each stimulus word was exposed for two seconds before the response word appeared beside it for another two-second period. The next stimulus word followed immediately, except that four seconds elapsed after each complete trial through the list. The subject was required to learn the ten pairs in list one to a criterion of three consecutive trials in which all response words were correctly anticipated. To control for serial position effects, the list was presented in three successive random orders of pairs before the first order was repeated. Three subjects failed to reach the criterion on list one within forty minutes and were not used further in the experiment.

After a pause of four minutes, each remaining subject was presented with either form 1 or form 2 of the test list. The subjects were instructed that the procedure was exactly the same as for the first list and were urged to do their best on the test list. Since one subject failed to reach the criterion of one trial in which all the response words were correctly anticipated, there remained twenty-three subjects for the final analysis of results. Twelve of these learned form 1 of the test list and eleven learned form 2.

For each subject, all correct anticipations and errors were tabulated for both list one and the test list. Measures used in the final analysis were: (1) the number of trials required to reach the criterion on list one; (2) the number of different mediated (D) and unmediated (X) responses anticipated on the first two trials in which any responses were correctly given; (3) the total number of correct responses made for the mediated (D) and unmediated (X) words during the test trials.

Control Experiment. Twelve additional female S's from the same population performed in a control experiment designed to allow a comparison of the learning of A-D and A-X pairs in a situation where associative chaining could not differentially contribute to the learning of the pairs. Instead of learning list one, these subjects first learned either form 1 or form 2 of the test list. The second list was the remaining form of the test list. Thus, in the control experiment, associative facilitation due to A $\rightarrow$ B $\rightarrow$ C $\rightarrow$ D linkages was not possible because the A-B associations of list one were not learned by any subject. The analysis of results for the control subjects was based on measures similar to those of the main experiment.

Results

Since two forms of the test list and two groups of subjects were involved in the design, the equivalence of the two lists and the two groups must be established before the combined results can be dealt with. An analysis of the mean number of trials required to reach the criterion of learning on list one, which all subjects learned, indicated that the twelve subjects who subsequently learned form 1 of the test list did not differ significantly from the eleven subjects who subsequently learned form 2 of the test list. The mean for the former group was 25.00, with an S.D. of 9.17; and for the latter, 22.91, with an S.D. of 9.30. The t of .52 did not suggest an initial difference in learning speed between the

two groups. With respect to performance on the two forms of the test list, the mean number of correct anticipations per subject during learning did not differ significantly between forms 1 and 2. The means for forml and 2 were, respectively, 67.08 and 58.09 and the corresponding S.D.'s were 30.75 and 17.04. The Behrens-Fisher d of .87 did not allow rejection of the null hypothesis concerning form differences.

As a consequence of these comparisons, the results from form 1 and form 2 of the test list were combined. In order to determine whether the response terms for A-D pairs, for which associative chaining was possible, were more easily elicited during the early trials, an analysis was made of the responses on the first trial in which each subject made any correct anticipations. For all subjects there was a total of 58 anticipations. Of this number 34 were members of "chained" A-D pairs, as against 24 from "unchained" A-X pairs. The normal curve approximation to the binomial indicates that a result this large and in this direction would occur by chance less than 8 times in one hundred if the probabilities of successes for A-D and A-X pairs were equal. This suggestive finding prompted an analysis based on both the first and the second trials in which correct responses occurred. In this case the number of different correct anticipations for each subject over the two trials was tallied. This procedure, which still meets the assumption of independence, allowed the utilization of a larger N. It showed a total of 112 anticipations, 66 of which were members of "chained" pairs and 46, "unchained." The same one-tailed binomial test indicated that this result would occur by chance less than 3 times in one hundred if the probabilities of success for "chained" and "unchained" pairs were equal. The conclusion that "chained" words were more easily elicited during the early trials of learning seemed warranted.

The major purpose of the experiment, however, was to compare the ease with which chained and unchained pairs were learned. The design allowed this comparison to be made with each subject acting as her own control. Since each subject learned an equal number of chained (A-D) and unchained (A-X) pairs, the total number of correct anticipations by each subject for the unchained pairs was subtracted from the corresponding total for chained pairs. If there is facilitation of the learning of chained pairs (i.e., the subject has a larger number of correct anticipations on the A-D than on the A-X pairs) this difference will be positive. Over all subjects the mean difference between chained and unchained pairs was plus 3.74, with a standard deviation of 5.32. A t of 3.30 ($.01 > p > .001$) leads to rejection of the null hypothesis, and the conclusion that there was facilitation of learning of A-D pairs as contrasted with the learning of A-X pairs.

A secondary analysis of performance on form 1 and form 2 separately revealed that the direction of the difference between chained and unchained pairs was positive for both forms (form 1, $M = +4.92$, S.D. = 5.85; form 2, $M = +2.45$, S.D. = 4.31). For form 1, the t of 2.79 was significant at the .02 level of confidence. For form 2, the t of 1.80 was between the .15 and .10 level. This consistency of results was obtained despite the small N's involved.

It was recognized that, if for reasons other than associative chaining, the A-D pairs were as a group intrinsically easier to learn than the A-X pairs, the results obtained here could be accounted for on the basis of that factor alone. The control study was run to provide information about the relative difficulty

of A-D and A-X pairs in a situation where chaining of A-D pairs was not possible. The twelve subjects in the control experiment learned both form 1 and form 2 of the test list. The performance of these subjects on whichever form was learned last provided the basis for the analysis of the control experiment. First, the mean number of correct anticipations of the response word was determined for the ten A-D and the ten A-X pairs. The means were 7.06 and 7.35 respectively, with S.D.'s of 1.29 and 1.39. This difference did not approach significance and the direction of difference is unfavorable to the hypothesis that the A-D pairs were easier to learn than the A-X pairs. Finally, the two major analyses of the main experiment were repeated here. As Table 2 indicates, neither of the differences tested was significant, and in each case the direction of difference did not favor the A-D pairs. In the absence of the possibility of associative chaining, then, there was no evidence of easier learning of the A-D pairs used in this experiment.

Table 2

Summary of Major Results

Experiment	Initial Successful Anticipations (first two trials with correct R's) Chained (1)	Unchained (2)	Significance (1) vs. (2)	Total Correct Responses: Mean of chained minus unchained (3)	Significance of (3)
Main experiment	66	46	.03	+ 3.74	.01
Control experiment	24	27	Not signif.	-0.50	Not signif.

Discussion

Statistically, these results provide stronger evidence for mediational effects in learning than do the results of Bugelski and Scharlock(2). This is true in spite of the fact that the present experiment involves one more step in the chain of associations mediating the facilitated learning. Instead of an A-B-C sequence contributing to the learning of A-C, an A-B-C-D chain contributed to the learning of A-D. This demonstration of mediational influences extending over more than one intervening term, and involving language habits established prior to the experiment, offers some confirmation for theoretical explanations of thinking, problem-solving, etc., which have postulated the operation of such complex implicit associative sequences.

Of course, the highly significant results obtained here, in the face of less convincing evidence obtained in schematically simpler situations (2), raise the problem of accounting for this stronger effect. Two possibilities occur to the writers. First, it is probable that this experiment allowed a more efficient analysis by removing variability due to individual differences in learning ability. Whereas Bugelski and Scharlock endeavored to have each subject act as

his own control, their technique of analysis admittedly left some individual difference factors operating. Our procedure of using within-individual differences removed this variable and may have allowed mediational effects to be revealed more sensitively. Furthermore, it is at least conceivable that the pre-existing verbal habits of this experiment were stronger than the associations learned during the Bugelski-Scharlock experiment. It is probable that such strong associations, if such they were, brought about mediational effects more readily than weaker associations would have done.

The mere demonstration of mediational influences in learning, however, does not explain how the effect is achieved. The most plausible explanation would hold that the presence of an associative chain between the stimulus term and the response term in paired-associate learning increases the probability that the response term will be elicited in the learning situation. Any such elicitation would presumably have two effects. First, it would increase the total number of correct responses made during learning. This would be a performance change influencing the criterion measures used in this study. Second, there would be an influence on learning. The performance change, of course, does not necessarily reflect a change in the underlying learning process itself. Nevertheless, such a learning change is implied, since any factor which increases the frequency of occurrence of a correct response would increase the number of reinforced trials and thus indirectly influence the amount of learning.

Less obvious is the possibility that the differences between the mediated and unmediated pairs are due to interference effects in the learning of the control (A-X) pairs. Although interference due to the tendency for the A terms to elicit B was controlled by the design, possible differential interference effects may be seen when the entire A-B-C-D sequence is considered. If the probability of the elicitation of D is enhanced by the presence of A, as is stated above, then this tendency would compete with the elicitation of the correct response X in the unmediated pairs and possibly delay learning. It is entirely conceivable that the associative chains used here produced both a facilitative effect upon mediated pairs and an interference effect upon unmediated pairs. The possibility that these two effects of associative chains do operate is amenable to experimental test, although the design of this experiment and that of Bugelski and Scharlock (2) do not allow an analysis which would separate them.

Whatever the explanation of the mediational effect may be, there can be little doubt that it is the phenomenon underlying the superior performance of the subjects on the A-D pairs. The controls inherent in the main experiment plus the additional information from the control experiment leave little room for alternative hypotheses. Such factors as serial position, idiosyncrasies of words and subjects, etc., operated equally for the mediated and non-mediated pairs and could not account for the differences obtained.

The fact that questions following the experiment yielded no evidence that the subjects could verbalize the mediating terms only emphasizes the Bugelski-Scharlock conclusion that mediated association may be "unconscious."

Summary

This experiment was designed to study the effects of mediating verbal processes on paired-associate learning when the mediating process is implemented in part by pre-existing language habits and extends over more than one implicit verbal term.

First, ten chains of word associations, B-C-D, were constructed from normative data on association frequencies. Twenty-three female college subjects then learned a list of A-B pairs where the A terms were nonsense syllables and the B terms were the initial members of the chains described above. The test situation required that the subjects learn another list consisting of A-D and A-X pairs. The D terms were the final members of the associative word chains, and the X terms were not associated with any of the chains. A control experiment revealed that the A-D and A-X pairs did not differ in difficulty in the absence of chaining possibilities.

It was found that the A-D pairs were learned significantly faster, and elicited earlier in learning, than the A-X pairs. It was concluded that implicit verbal chains of more than one link mediated these effects. Reasons for these results being even more clear-cut than those of schematically simpler previous experiments were discussed.

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